A SIMPLE HIGH PERFORMANCE HORN DESIGN*

J. T. SHAFFER, D. E. PING, AND R. B. DYBDAL
THE AEROSPACE CORPORATION

A simple horn antenna is described featuring a low sidelobe pattern and a low loss septum polarizer. The horn provides a relatively high G/T from a compact package. Measured results compare well with analyses using HFSS modeling.

I. Background and Design Rationale

The development of this horn antenna was motivated by requirements for meteorological data readout of RDS (Real Time Data Smooth) service, the low resolution data broadcast by the DMSP satellite. A compact antenna having a high G/T is needed with the potential for low cost manufacture. While parabolic reflectors are typically used for satellite data readout, the small electrical size for this application poses inherent efficiency limitations. Horn antennas achieve high efficiency and low sidelobe patterns maximize directivity and limit antenna temperature contributions from ground emissivity. Normally, such requirements are satisfied by a corrugated horn, but their manufacture is relatively expensive.

The horn developed for this application has a square aperture and a septum polarizer to achieve the required circularly polarized pattern with low loss. A low sidelobe pattern was achieved by terminating the aperture with rounded edges (Ref. 1). A relatively large input waveguide was used to reduce the horn's length.

II. Analyses and Measurement

The horn antenna pictured in Fig. 1 shows the rounded edge terminal of the square aperture and the septum polarizer. This horn was constructed from aluminum and in two components, the aperture and the septum polarizer section connected by the circular flanges. At 2.2225 GHz, the dimensions of the horn in wavelengths (λ) are: an aperture of 1.88 λ square, a semi-circular edge of 0.47 λ diameter, and the input waveguide section of 0.75 λ square. The half-flare angle of the horn is 30 degrees.

The measured VSWR of the horn in Fig. 2, illustrates a well matched response over a wide bandwidth. The horn patterns in Fig. 3a-c were measured using a rotating linear source to observe the polarization variation. These measured patterns reveal the desired low sidelobe response that contributes to high directivity and achieves a low antenna temperature by minimizing ground emission contributions. The measured patterns are taken in two principal planes and the diagonal plane. The principal plane beamwidth is 33^o and the axial ratio in the main beam region is about 2 dB.

The measured gain of this horn is 14.2 dBic and its directivity is 14.6 dBic. The

*This work was supported under NOAA Contract 50-SPNA-0-00012

measured antenna temperature of the horn is 21.5K and 34.7K at 90^o and 20^o elevation angles respectively. The measured antenna temperature and the sky temperature at the 90^o elevation angle results in the conclusion that the insertion loss of the horn is about 0.25 dB. With a bandpass filter loss of 0.4 dB, and a receiver noise figure of 0.8 dB, the G/T of the overall terminal design is –6.0 and –6.4 dBi/K at 90^o and 20^o elevation angles, respectively. While this horn was specifically designed for a 2.2225 GHz frequency allocation to be used by future satellites, very comparable performance is also achieved at the 2.2075 and 2.2575 GHz allocations used by existing satellites. The principal limitation in the bandwidth of this horn is the growth in its axial ratio with increasing bandwidth. A stepped septum polarizer in place of the linear septum that was used to simplify this horn's design would increase the bandwidth over which the axial ratio is maintained. A stepped design can be used in applications requiring wider bandwidths.

The horn design was analyzed using HFSS software to verify the design parameters and explore design tradeoffs. These analyses agree well with measured results. Calculated patterns in Fig. 3d for the principal and diagonal planes follow the measured results. Analyses comparing perfectly conducting and aluminum geometries reveal a calculated insertion loss of 0.2 dB, that agrees with the 0.25 dB loss deduced from the measured antenna temperature values. The analyses also compared the horn with the rolled edge to one not having the rolled edge. The reduction of the sidelobes and backlobes achieved with the rolled edge increased the directivity by 0.4 dB illustrating the benefit of the rolled edge. The septum polarizer and the input waveguide dimensions were verified with HFSS to provide good axial ratio performance and isolation between senses of circular polarization. The VSWR values from the HFSS analyses agree well with the results in Fig. 2. The HFSS analyses also verify that mode conversion does not occur within the throat region of the horn, and the measured results likewise indicate no evidence of mode conversion.

III. Summary

Experience with a simple horn design illustrates low sidelobe patterns and relatively high G/T performance can be obtained in a compact package. The bandwidth of the horn is more than adequate for its intended application. The design of this horn should lend itself to cost effective manufacture.

Reference

W. D. Burnside and C. W. Chuang, "An Aperture-Matched Horn Design," IEEE Trans Antennas and Propagation AP-30, pp 790-796, July 1982

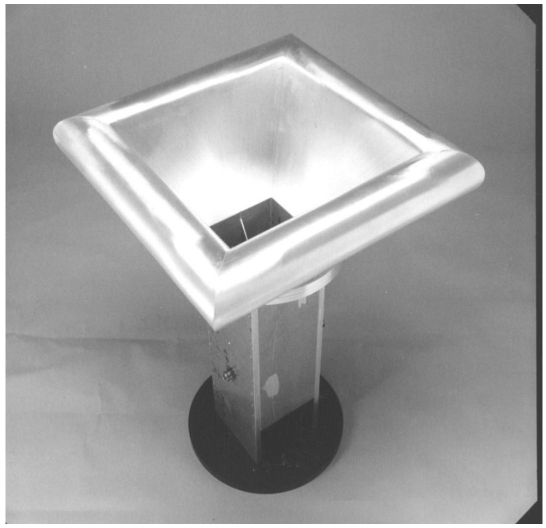


Fig 1. Experimental Horn Model

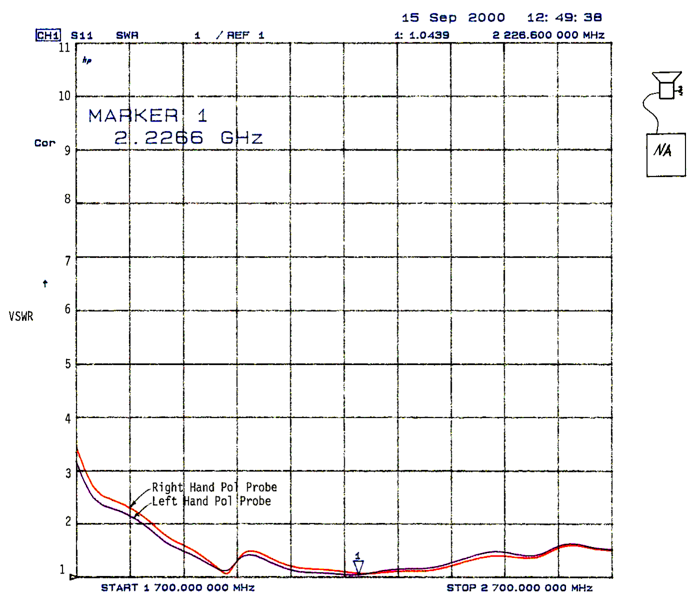
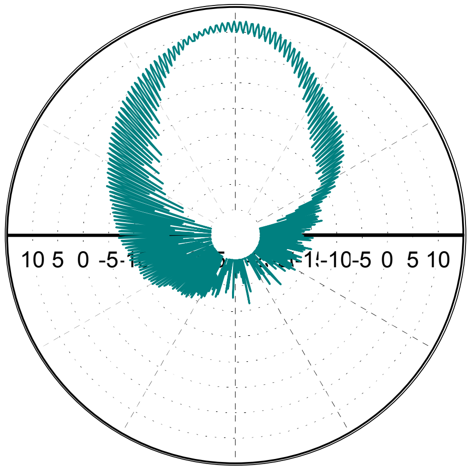
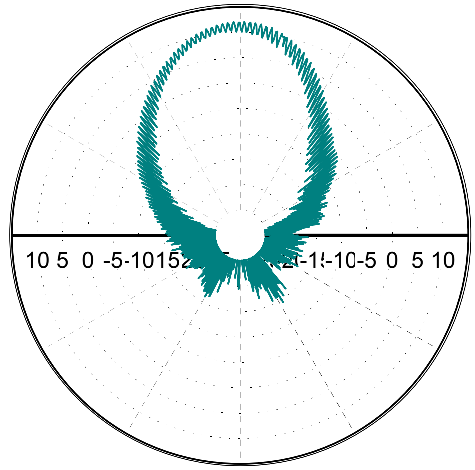


Fig 2. Measured VSWR of Horn



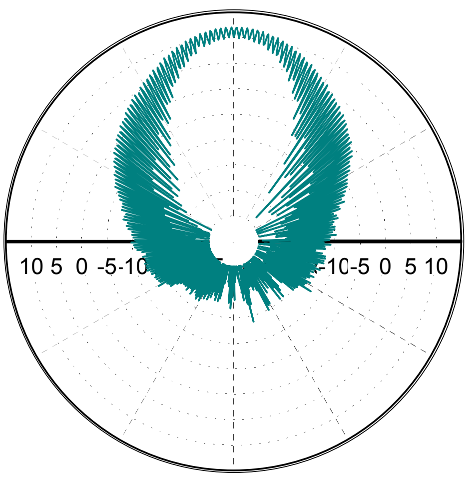
Phi = 0 deg.

(a) Principal Plane



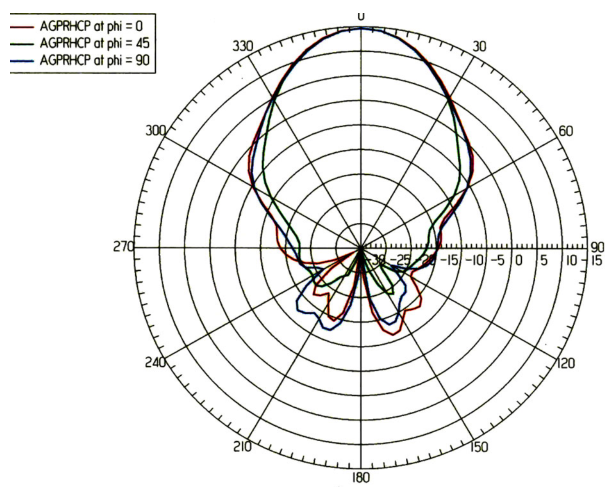
Phi = 45 deg.

(b) Diagonal Plane



Phi = 90 deg.

(c) Orthogonal Principal Plane



(d) Calculated Patterns

Fig. 3 Measured and Calculated Patterns